

Gender Identification in Digital X-ray Images of Femur Bone

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Abstract—The digital X-ray images carry huge amount of information about various diseases from which the patient is suffering. The recent studies are concerned about medico-legal factors. In this paper, we have proposed a technique of gender identification from the digital X-ray images of femur bone. The images are captured at a distance of 135-centimeters and the machine zooming was maintained uniformly for all the images. The experimental results indicate that male femoral angle is above 136° and below 143° , whereas female femoral angle is above 141° and below 146° , from which the differentiation of male and female can be done.

Keywords—Femur bone; femoral angle; Digital X-ray images.

I. INTRODUCTION

Medical image processing is one of the fastest, non invasive and result oriented technology employed in the modern era [5][12] of forensic and medico-legal domain. However, human ability of gender identification for a person is based on the prior anatomical knowledge. But performing the same accuracy based on the digital X-ray platform becomes more challenging. Moreover, the substantial trust of domain experts on recent computer algorithms should be maintained high [11][3][6]. Herein the proposed work begins with the acquisition of the digital X-ray images of the femur bone from the living patients and then processing the acquired images using digital image processing tools to analyze those images [4]. The digital X-Ray is an imaging technique where X-rays are passed through the patient's body and the rays which are passed will carry information and the console attached to the digital X-ray machine will scribble out with the image of particular body part on where the digital X-ray gun was focused with the help of sensors present on the other side of the body [9][10][13]. Therefore, the resultant digital X-ray image consists of homogeneous spatial intensity needed for the further processing [1]. The study concentrates on the medical and medico-legal factors of the information present in the X-ray images. The body consist of many bones and structures which give clue about the gender of a person. But studying the same bones and structures in the form of digital X-ray images makes work more complicated[14].The proposed study considers the digital X-ray image of the right femur bone, from which extraction of the femoral angle is determined [2][7]. Femur bone is the one which is present in between the hip joint and

the knee [17][8]. It can be described as the longest bone in the human body and femoral angle is the angle made by the line defining the length of the femoral neck and its junction with the line defining the mid line of the shaft of the femur[15][16]. The Fig.1 depicts what exactly the femoral angle is about.

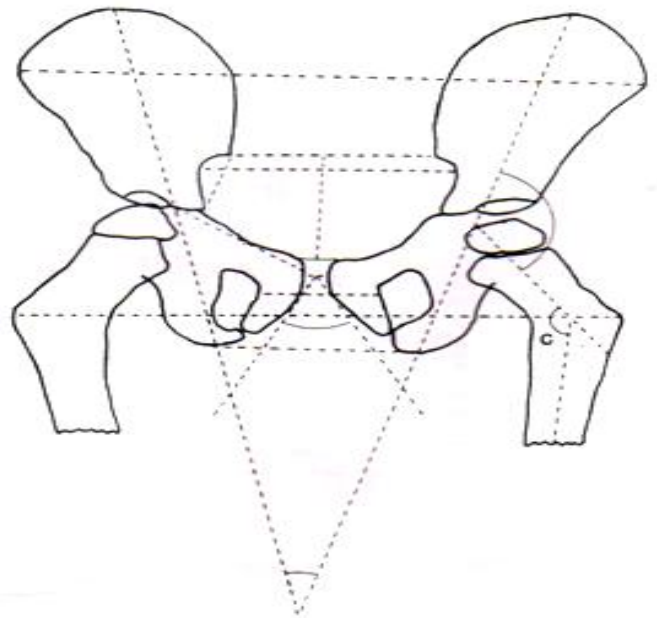


Figure 1. The femoral angel C.

II. METHODOLOGY:

The proposed methodology comprises the following steps:

1. Converting X-ray image into JPEG format
2. Apply canny edge detector
3. Consider only the longest edge which represents the femur bone.
4. Determine the angle of femur bone.

The procedure for determination of femur bone angle is as described below.

The list of pixels the pixels of longest edge is created. The end points and centre point of the longest edge are determined. The angle θ between the two line segments, one line \vec{x} joining starting point and central point and the other line \vec{y} joining the

central point and terminal point, is determined by using the formula given in the (1):

$$\Theta = \cos^{-1} \frac{\vec{x} \cdot \vec{y}}{|\vec{x}| |\vec{y}|} \quad (1)$$

The images are not subjected to any pre-processing stages, algorithm is given as below.

Algorithm 1: Femur bone angle determination

Input: X-ray image of femur bone

Output: Femur bone angle

Step 1: Input X-ray image I (in XLS format).

Step 2: Convert image I into image I₁ in JPEG format.

Step 3: Crop the subimage I₂ of I₁ with femur bone at the centre (by visual inspection).

Step 4: Apply canny edge detector to I₂ and generate edge image I₃.

Step 5: Retain the longest edge (which represents femur bone) and remove the remaining edges of I₃ to give the resultant image I₄.

Step 6: Mark start, end and mid points on the longest edge. And join these points with straight line.

Step 7: Overlap the image I₄ in cropped image I₂.

Step 8: Find angle between the lines joined from Step 6 to differentiate male and female femoral angles.

The resultant images in various stages of algorithm are shown in Fig. 2. The details of the sample collected and experimental finding have been recorded in the Table 1.

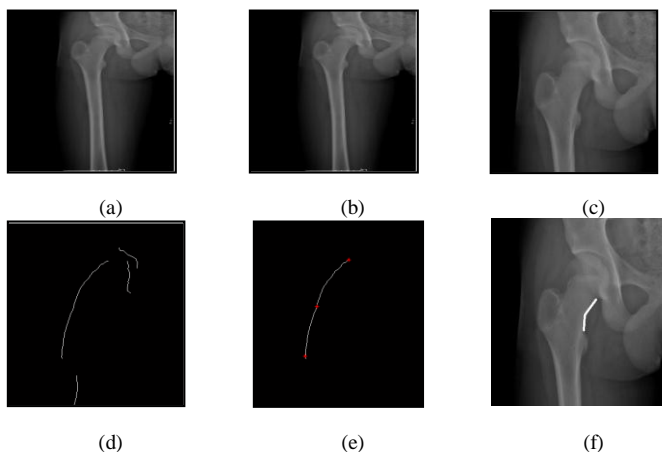


Figure 2. Input image and resultant images of the proposed method: (a) Input image I (b) Image I converted to JPEG format I₁ (c) Cropped image I₂ (d) Edge image I₃ (Canny edge detector) (e) Edge image I₄ with longest edge (f) Overlapped image of images in (e) and (c).

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

For the purpose of experimentation, 100 bone digital X-ray images are considered for training. Out of which 60 are used with 30 male and 30 female bone images. The experimentation of proposed method is carried out on dual core i5 processor at 2.30 GHz and matlab 7.0. From the training images femoral angle is determined. The maximum, minimum, mean and standard deviation of femoral angle values for male and female are computed and stored as knowledge base as is shown in the Table 1. The Algorithm 2 is used to compute femoral angle for training images.

TABLE I. KNOWLEDGE BASE OF FEMUR BONE ANGLES FOR MALE AND FEMALE

Gender	No.of. training Samples images	Min C _{min}	Max C _{max}	Mean \bar{C}	Std.Dev σ
Male	34	136 ⁰	143 ⁰	138.085 (C _m)	8.691 (σ_m)
Female	26	141 ⁰	146 ⁰	145.327 (C _f)	6.171 (σ_f)

Algorithm 2: Femoral angle determination for training images

Input: Femur bone digital X-ray of male/female

Output: Gender determination

Step 1: Input digital X-ray image I (training image).

Step 2: Determine femoral angle C. Using the Eq. (1).

Step 3: Repeat Step 1 and Step 2 for all training images.

Step 4: Find the minimum C_{min} and maximum C_{max} values of C. Also compute the mean angle (C_m, C_f) and standard deviation (σ_m , σ_f) of femur bone for male and female, and store in the knowledge database (Table 1).

Step 5: Stop

Now the remaining 40 images are considered for testing purpose. The Algorithm3 for test cases is as given below:

Algorithm3: Femoral angel determination for test images

Input: Femur bone digital X-ray of male/female(Test)

Output: Gender determination

Step 1: Input the test digital X-ray image of femur bone.

Step 2: Compute femur bone angle C using Algorithm 1.

Step 3: Classification Rule 1:

If $C_{min-male} \leq C \leq C_{max-male}$, then gender is male;

If $C_{min-female} \leq C \leq C_{max-female}$, then gender is female;

Otherwise gender is unknown.

Classification Rule 2:

If $\bar{C}_m - \alpha\sigma_m \leq C \leq \bar{C}_m + \alpha\sigma_m$, then gender is male;

If $\bar{C}_f - \alpha\sigma_f \leq C \leq \bar{C}_f + \alpha\sigma_f$, then gender is female;

Otherwise gender is unknown.
where value of α is empirically fixed ($\alpha=0.8$)

Step 4: Output gender of femur bone.

Out of the 40 test images, 16 are identified as male femoral bone, whereas, 17 are identified as female femoral bones and the remaining 7 are misclassified. The accuracy of classification Rule 1 is 80% and 85% for male and female. Similarly for classification Rule 2, it is 80% and 90% for male and female respectively. Samples of correctly identified femoral angles of male and female are shown in Fig.3. The confusion matrices for Rule 1 and Rule 2 are given in Table 2 and Table 3 respectively.

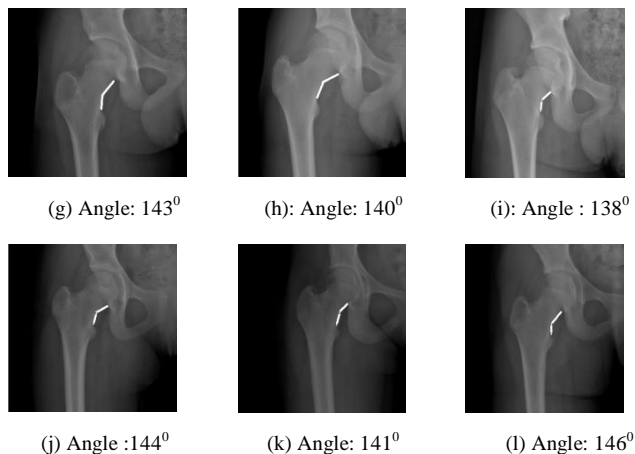


Figure 3. Sample resultant images (g) (h) (i) for male and (j) (k) (l) for female.

TABLE II. CONFUSION MATRIX USING CLASSIFICATION RULE 1 OF ALGORITHM 3.

	No. Of test image Samples	Male	Female	Unknown
Male	20	16	02	02
female	20	01	17	02

TABLE III. CONFUSION MATRIX USING CLASSIFICATION RULE 2 OF ALGORITHM 3.

	No. Of test image Samples	Male	Female	Unknown
Male	20	16	01	02
female	20	01	18	02

IV. CONCLUSION

In this paper we have examined detection of femoral angle in the femur bones of human from the digital X-ray images. Considering hundred samples for femoral angle identification and implementing classification Rules on the test images, accuracy of gender identification in male and female is 80%

and 85% respectively using classification Rule 1, and 80% and 90% using classification Rule 2 for male and female respectively. But the future work can be carried out to increase the rate of accuracy. The complexity of studying digital X-ray images have made easy from the proposed work, whereas, medical and medico-legal society will be more benefited from the continuous study about the domain.

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